

Computer Networks

Chapter 6

Physical Layer

Chapter 6: roadmap

- What drives our network:
 - Transmission media
 - Physical connectors
 - Cabling

Chapter 6: roadmap

- Introduction
- Transmission media
- Connectors
- Ethernet physical layer

Transmission basics

■ Simplex Communication

- Data flows on one directions
 - Television, Radio

■ Half Duplex

- Transmission on one direction at a time
- Uses a turn around mechanism
- Over – Like on walkie-talkies (two-way radio receivers)
- Collision may happen

■ Full Duplex

- Transmission on both ways simultaneously
- Different data paths
- No collisions

Synchronization

- Transmitter and receiver need to be in sync
 - Need to know where to start sampling bits
 - Need to know where a frame starts and ends
- Bit synchronization
 - In-band
 - Clock extraction from data signal
 - Out-of-band clock sync
- Frame synchronization
 - Start and end of frame delimiters
 - Using special flags (e.g. 01111110)
 - Ensuring that flags do not appear on data (e.g. 5 sequential 1s at most)

Transmission media

- Guided

- Copper wire
- Fibre optic cable

- Unguided

- Wireless (Radio, Microwave)

- Information transmitted over:

- Copper – by varying the voltage or current over time
- Fibre optic – by pulsing light on/off over time
- Radio waves or Microwaves – by varying the frequency or amplitude over time

Guided transmission basics

- To transmit a single bit on a copper wire, we must send some electrical signal having two discrete states to represent 0 and 1
- Examples:
 - Voltage $+5\text{v} = 1$ $0\text{v} = 0$
 - Frequency $980\text{Hz} = 1$ $1180\text{Hz} = 0$
- If a second bit follows the first
 - We need to find a mean of indicating the bit boundary or synchronizing the receiver with the transmitter to agree where a bit starts and ends

Chapter 6: roadmap

- Introduction
- **Transmission media**
- Connectors
- Ethernet physical layer

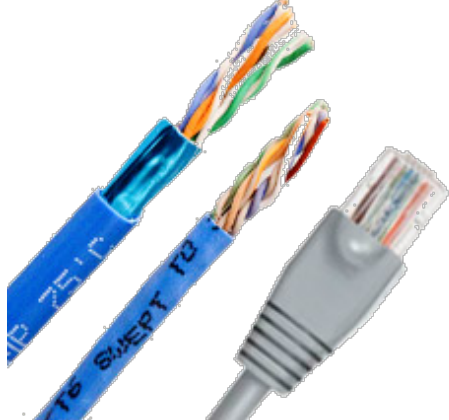
Guided transmission media

- Where the signal is sent

- Copper or Fibre

- Copper:

- Twisted pair: Two or more insulated wires, twisted together in order to reduce external interference



- Cat 5/5e

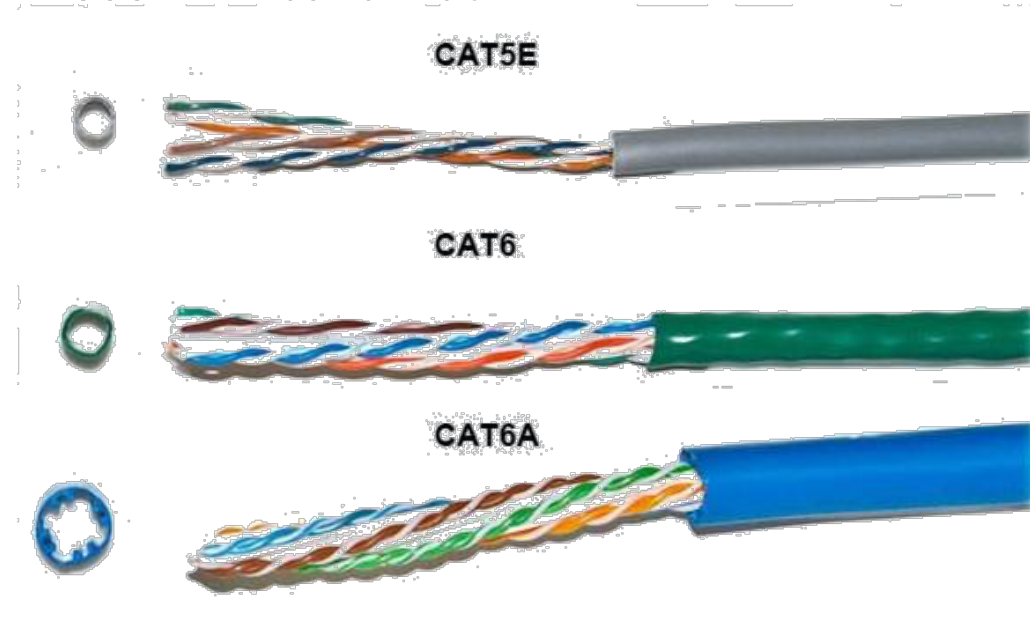
- 100 MHz bandwidth

- Cat 6

- 250 MHz bandwidth

- Cat 7

- 600 MHz bandwidth



Shielding types



**Unshielded
Twisted Pairs (U/
UTP)**



**Foiled with
Unshielded Twisted
Pairs (F/UTP)**



**Shielded with
Unshielded Twisted
Pairs (S/UTP)**



**Shielded and Foiled
with Unshielded
Twisted Pairs (SF/UTP)**



**Unshielded with
Foiled Twisted
Pairs (U/FTP)**



**Foiled with Foiled
Twisted Pairs (F/
FTP)**



**Shielded with
Foiled Twisted
Pairs (S/FTP)**

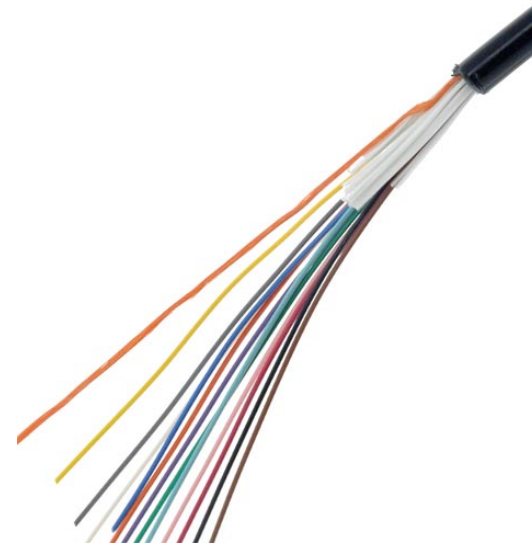
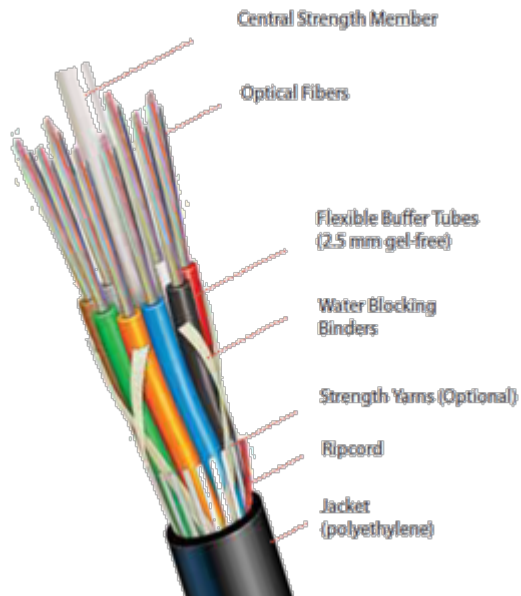


**Shielded and Foiled
with Foiled Twisted
Pairs (SF/FTP)**

Guided transmission media

■ Fibre optic cable

- Central glass core, surrounded by glass cladding of lower refractive index, in order for the light to stay in the core
- Plastic jacket on the outside
- Many fibres bundled together by another plastic sleeve or armour



Light transmission

- Source of light is usually a LED or a Laser
- The source of light transmits the light to a light detector
- The light detector is usually a photo diode
 - Converts light to electrical signals
 - Response time limits the data rate
- Fibre modes
 - Multimode
 - Light dispersed through multiple paths
 - 50-100 microns (62.5 is common) = Width of a human hair
 - Used in short distances (less than one Km)
 - OM1 to OM4 (optical mode = different windows)
 - OM3 and OM4 are for transmissions above 10Gbps
 - Single mode
 - Light travels in straight line
 - 8.3-10 microns
 - Use lasers
 - Long distances (hundreds of kilometres)

Fibre: characteristics

■ Advantages

- Higher data rates
- Lower attenuation
- Not affected by power surges, electromagnetic interference, corrosive chemicals
- Difficult to tap
 - Better for security
- Thin and lightweight
- Cheaper

■ Disadvantages

- Skills in order to make fusions
- One way only
- Expensive interfaces

Unguided transmissions

■ Radio waves

- Penetrate buildings
- Can travel long distances
- Omni-directional (transmit both ways)
- Transmitter and receiver do not need to be in line of sight
- Subject to interferences from motors and other electrical equipment

■ Microwaves

- Above 100MHz, waves travel in straight lines and can be focused on small beams using special parabolic antennas
- Transmitters and receivers need to be aligned
 - Multiple TX and RX can be setup in parallel
- Typically do not pass through solid objects

Chapter 6: roadmap

- Introduction
- Transmission media
- **Connectors**
- Ethernet physical layer

Connectors

■ Copper

- 8P8C (AKA RJ45)

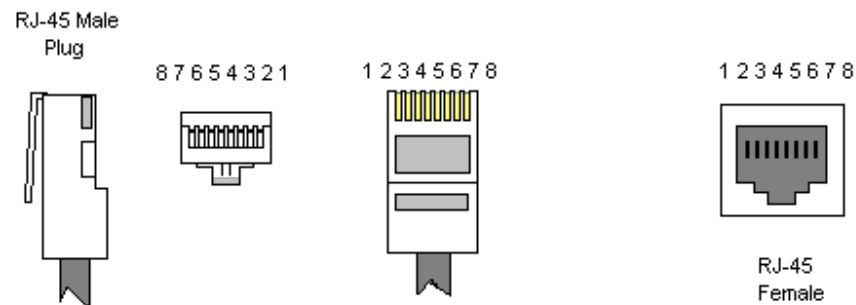
■ Fiber

- LC
- ST
- SC
- E2000
- ...

■ Other Interfaces

- AUI (10Mbit Ethernet)
- MII (100Mbit Ethernet)
- XAUI (10Gbit Ethernet)
- GBIC (Gigabit Ethernet)
- SFP/SFP+/QSFP (multi protocol: ethernet, fiber channel, etc.)
- ...

Copper connectors



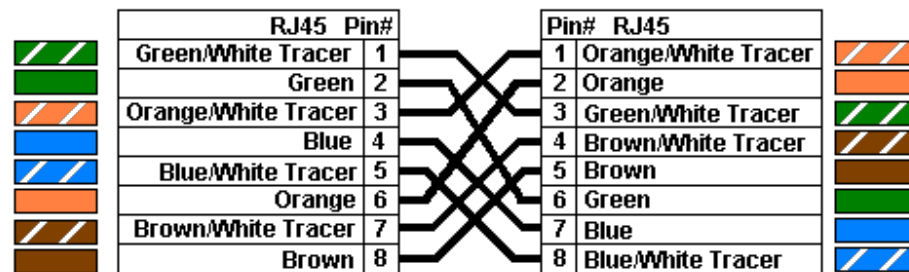
Color Standard
EIA/TIA T568A

Ethernet Patch Cable



Color Standard
EIA/TIA T568A

Ethernet Crossover Cable



"A" is earlier

Transceivers



Transceivers



Chapter 6: roadmap

- Introduction
- Transmission media
- Connectors
- Ethernet physical layer

Ethernet physical layers (Copper)

- 10Base-T
 - Cat 3 or Cat 5
- 100Base-TX (AKA 100Base-T)
 - Cat 5
- 1000Base-T
 - Cat 5, 5e, 6 and 7
- 10GBase-T
 - Cat 6 = 55m
 - Cat 6a and 7 = 100m

Ethernet physical layers (Fibre)

- 10Base-FL
- 100Base-FX
 - Multi-mode Fibre
 - 400m Half-Duplex, 2Km Full-Duplex
- 100Base-SX
 - Retro-compatible with 10Base-FL with auto-negotiation
- 1000Base-SX
 - Multi-mode Fibre (550m)
- 1000Base-LX
 - Multi-mode Fibre (550m)
 - Single-mode Fibre (2Km to 10Km)
- 1000Base-ZX
 - Single-mode Fibre
 - Up to 100Km

Ethernet physical layers (Fibre)

- 10GBase-SR
 - Multi-mode (up to 400 meters with OM4 fibre)
- 10GBase-LR
 - Single-mode (10Km)
- 10GBase-ER
 - Single-mode (40Km)
- 40GBase-SR4/100GBase-SR10
 - Multi-mode (OM3 100m, OM4 150m)
- 40GBase-LR4/100GBase-LR4
 - Single-Mode (10Km)
- 100GBase-ER4
 - Single-Mode (40Km)

Chapter 6: done!

- Transmission basics
 - Communication modes
 - How to synchronize a receiver with a transmitter
- Guided vs unguided transmission
- Transmission media
 - Cabling
 - Copper vs Fibre
- Connectors
- Ethernet Physical Layers